CHAPTER 11 TIMBER-PILE WHARVES

Wharves are used for loading and unloading ships. This chapter describes how a carpenter constructs a timber-pile wharf. The topics covered include—

- *Layout and installation of piles for pile-wharf construction.*
- *Construction of a wharf superstructure.*
- *Installation of docking hardware.*

(For more detailed information on timber-pile wharves, see FM 5-480.)

TYPES OF WHARVES

Wharf is an overall term that applies to any waterfront structure designed to make it possible for vessels to lie alongside the shore for loading and unloading. The term *wharf is* confined in practice to the T- and U-type *marginal* wharves (Figure 11-1, page 11-2). A marginal wharf usually consists of a timber or steel superstructure supported by a series of timber, steel, or concrete pile bents.

The other structures shown in Figure 11-1 are called *piers,* except the *quay. A* quay is a reinforced landing place made toward the sea or at the side of a harbor. All structures shown in Figure 11-1 may consist of fill supported by bulkheads.

TYPES OF PILES

To protect a wharf against normal wear and tear, three types of piles are used: bearing, fender, and mooring piles. The types of piles are discussed in the following paragraphs:

BEARING PILES

Bearing piles support the wharf or pier framework and decking. The piles should be straight and measure at least 6 inches across the top, 18 inches across the butt (bottom), and from 60 to 80 feet in length. Pile length varies according to the depth of the water and condition of the bottom. Bearing piles should be spaced from center to center 6 to 10 feet apart in one direction and 5 feet apart in the other direction.

FENDER PILES

The force of a moving ship coming in direct contact with bearing piles is enough to collapse an unprotected wharf. To protect and absorb the initial shock, fender piles are placed about 2 1/4 feet out from the centerline of the outside row of bearing piles. These piles are placed about 18 feet

apart and along the sides where ships dock.

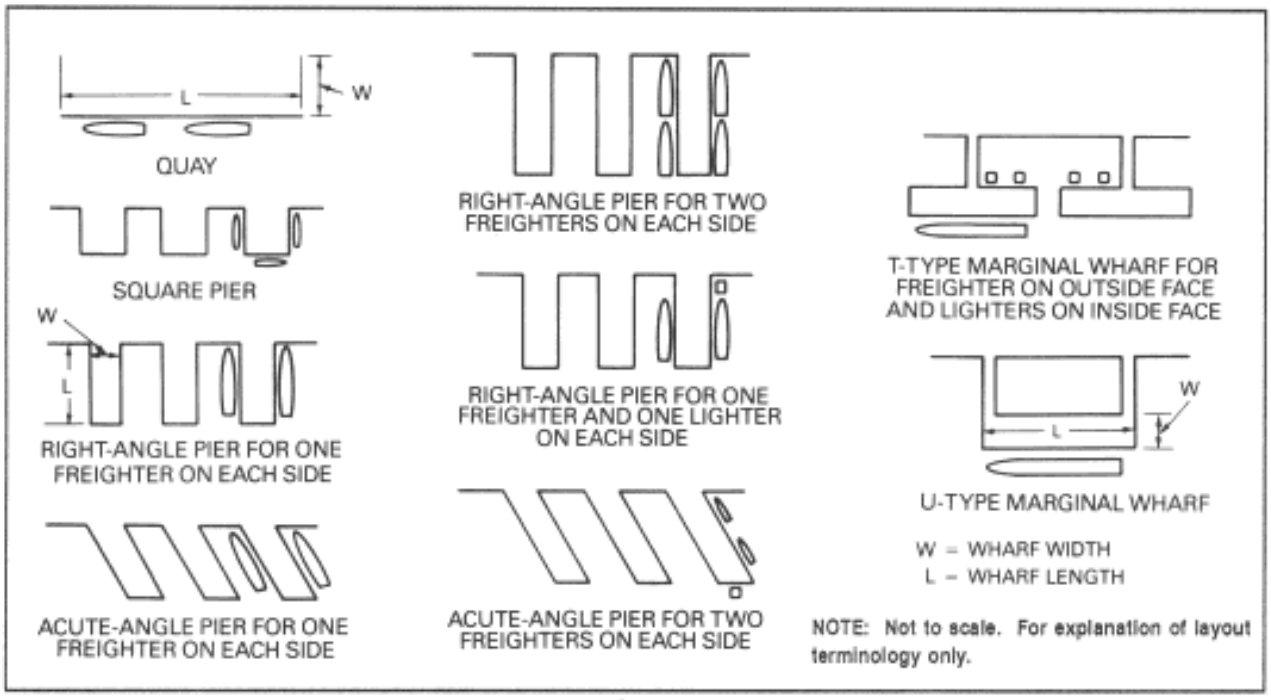

Figure 11-1. Common wharves

MOORING PILES

Mooring piles are aligned with the outside row of bearing piles and are spaced about 30 feet apart. This type of pile is braced along the outside row of bearing piles and usually extends to about 4 feet above the floor (or deck) of the platform. The 4-foot extension provides ample space to secure mooring lines.

NOTE: **Timber piling must be treated with creosote or some other preservative Compound to protect it from fungi and marine borer attacks.**

INSTALLATION OF PILES

Pile-driving equipment and the methods of driving and pulling piles are covered in FM 5-480. The equipment is operated by a special crew, but the carpenter is present during the pile driving to direct the alignment of the piles.

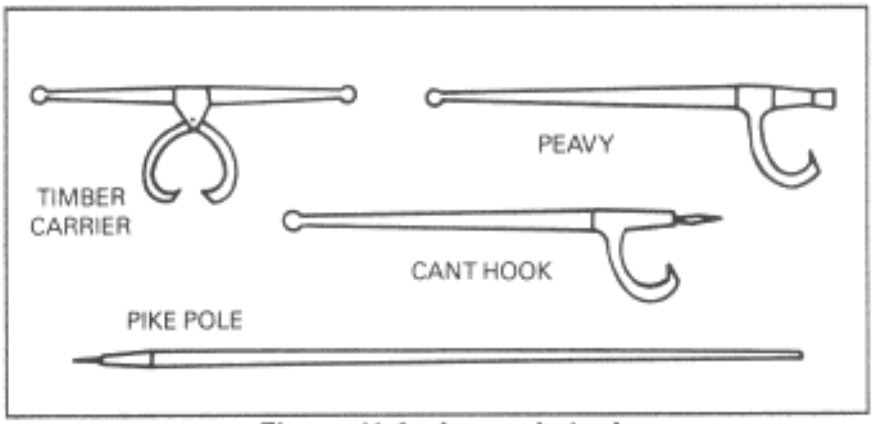

Figure 11-2. Logger's tools

USING SPECIAL TOOLS

Since most of the heavy

timbers used to build waterfront structures cannot be manhandled, special tools, known as logger's tools (Figure 11-2), are used to move and place these timbers. They consist of—

- *Peavy and cant hooks.* Lever-type tools, used mainly to roll timbers.
- *Timber carriers.* Two-man tools, used mainly to pick up and carry timbers.
- *Pike poles.* Used to hold or steady timbers while they are being placed.
- *Cranes.* Normally, two men are assigned to a crane: the operator and the helper. The helper drives the crane carrier (truck) and hooks and unhooks loads. Using standard signals, the helper tells the operator when to lift and lower the load and where to position it. After the heavy timbers have been moved and placed, the carpenter's level is used to level them properly.

NOTE: Although the crane cannot be considered a special tool, it is mentioned here because of its use to raise and lower heavy timber.

STRAIGHTENING PILES

Piles should be straightened as soon as any misalignment is noticed. The desired accuracy of alignment varies with each job; however, if a pile is more than a few inches out of plumb, it should be set true. The greater the penetration along the wrong line, the more difficult to get the pile back into plumb. To realign piles, use one of the following:

- A block and tackle (Figure 11-3), with the impact of the hammer jarring the pile back into line.
- A jet (Figure 11-4, page 11-4), either alone or in conjunction with a block and tackle.
- A block and tackle and an alignment frame (Figure 11-5, page 11-4) to pull the piles In a bent into proper spacing and to align them after they have been driven.

When a floating pile driver is used, a frame (template) for positioning piles may be fastened to the hull. A floating

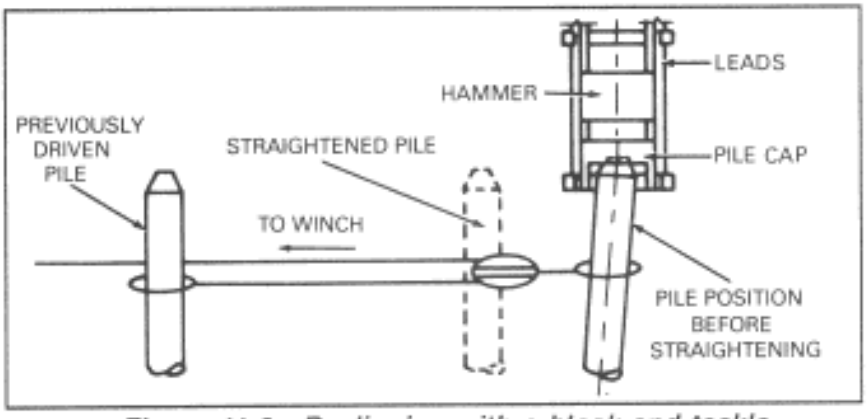

Figure 11-3. Realigning with a block and tackle

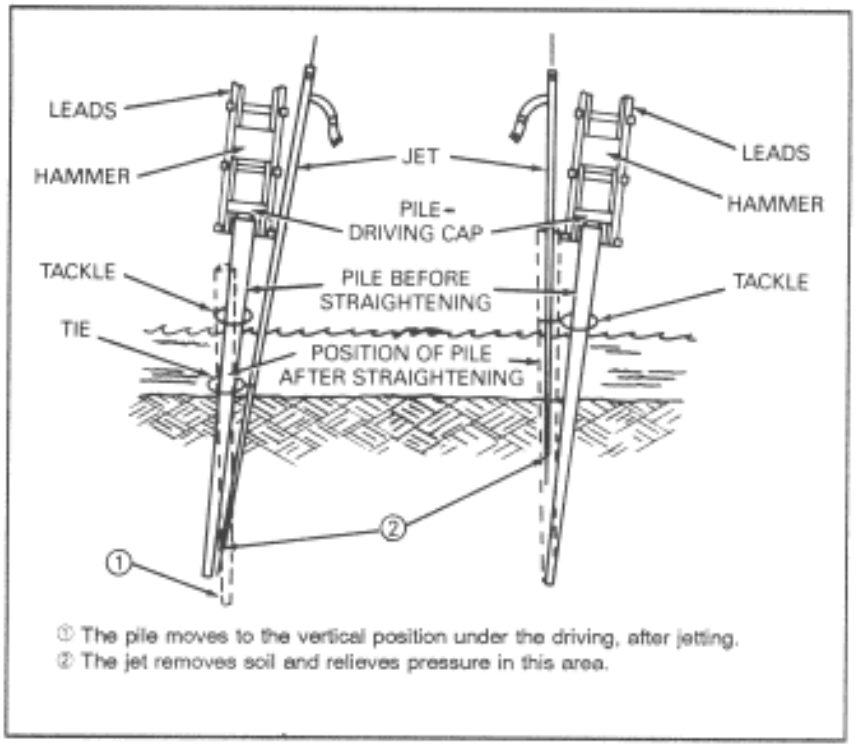

Figure 11-4. Realigning with a jet

template (Figure 11-6, page 11-6) is sometimes used to position the piles in each bent. The spacing of battens is such that the centerline between them is on the pile line desired. Battens are placed far enough apart so that, as the pile is driven, the larger diameter butt end will not bind on the template and carry it underwater.

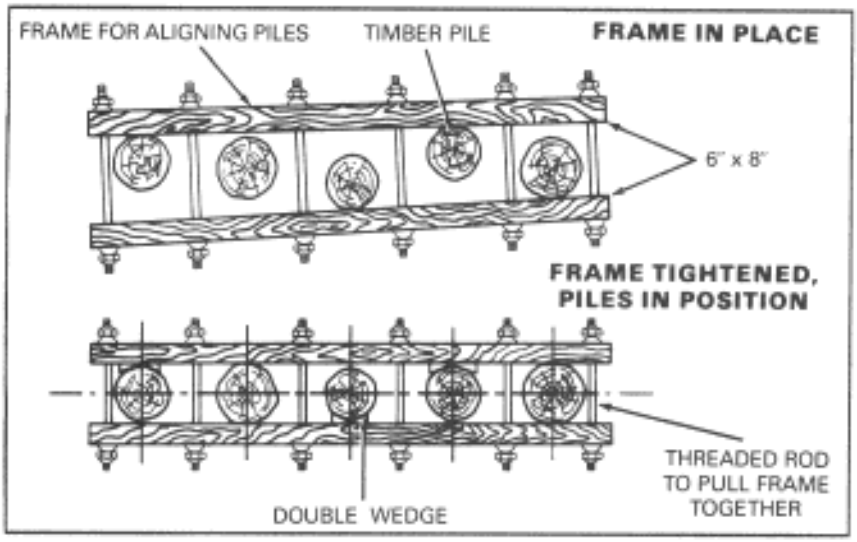

Figure 11-5. Realigning with a frame

A chain or collar allows the template to rise and fall with the tide. If the ends of the battens are hinged and brought up vertically, the template may be withdrawn from between the bents and floated into position for the next bent. Several templates may be used for a bent; or a single template is moved, if the pile spacing is uniform. The position of the piles is controlled as follows:

Step 1. After each bent has been driven, a line is run back from each pile in the outer bent to the corresponding pile in each of the next several bents shoreward.

Step 2. The alignment and longitudinal spacing of the outshore bent are verified.

Step 3. Any deviation in position of previously driven piles is made up when the template is positioned for the next bent. Piles that are slightly out of position may later be pulled into place as described previously in the first paragraph.

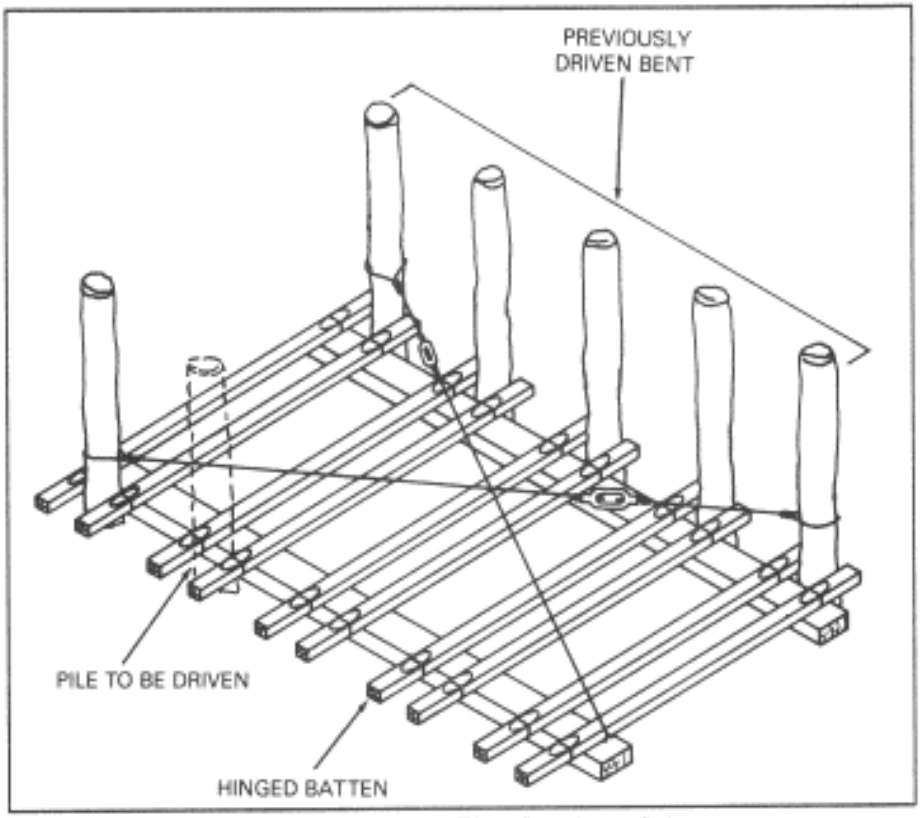

Figure 11-6. Floating template

CUTTING PILES

The lengths of pile selected for a structure should be such that the butts are 2 or 3 feet higher than the desired finished elevation after driving to the desired penetration. Since the pile capping should bear

evenly on every pile in the bent, trimming should be carried out accurately by nailing saw guides across all piles in the bent. Figure 11-7 shows cutting piles.

CAPPING TIMBER PILES

Caps are large timbers placed on top of the timber-bearing piles to support the superstructure. The pile capping is fastened as shown in Figure 11-8, page 11-6, and as follows:

Step 1. After the piles have been cut, the cap is put in place; a hole for a driftpin is bored through the cap into the top of each pile; and the driftpins are driven into the holes.

Step 2. At a joint between pile cap timbers, a splice scab is bolted across the joint to each side of the pile cap.

Step 3. The working platform, aligning cables, or spacing frame may then be removed, since the driftpins will hold the piles in the proper position.

BRACING PILES

Bents are braced as shown in Figure 11-8 and as follows:

Step 1. Bolt diagonal timbers to each pile with the bracing running in one diagonal direction on one side of the bent and in the opposite diagonal direction on the other side.

Step 2. If the piles in a bent differ a lot in diameter at the point of bracing, make one of the following corrections:

- Large piles may be flattened down with an ax (hewed or dapped).
- Small piles may be blocked out with filler pieces.
- The flexibility of the braces may be used to pull them tight against the piles.

(Figure 11-9, page 11-6, shows transverse bracing.)

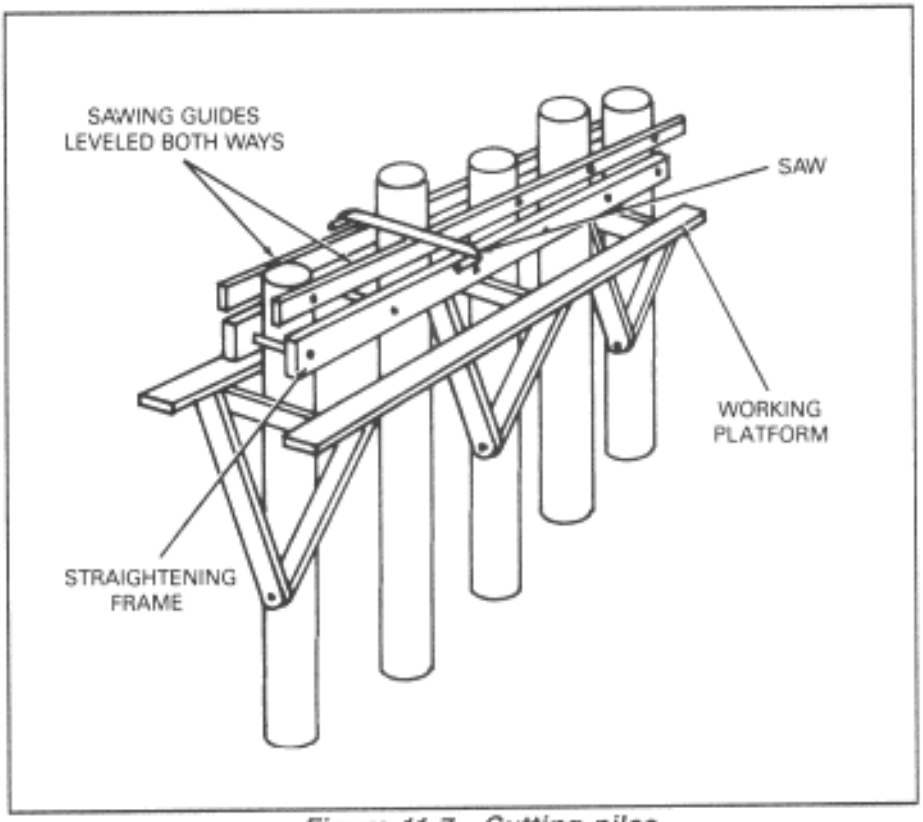

Figure 11-7. Cutting piles

WHARF SUPERSTRUCTURE

After the timber pile bents have been aligned, braced, and capped, the construction of the wharf superstructure is begun. Building the superstructure consists of installation of the stringers, the decking, and the curbs or stringpieces; and erection of the fender systems. Figure 11-10 shows stringers and decking in place.

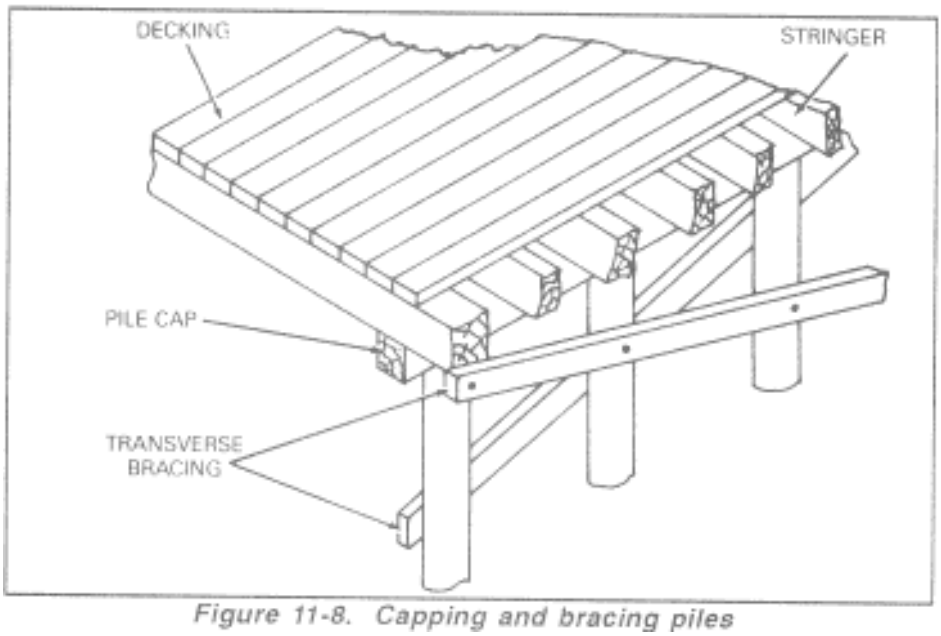

Figure 11-8. Capping and bracing piles

STRINGERS

Stringer positions are measured from the centerline of the wharf. The stringers are toenailed to the pile caps with two 3/8- x 10-inch spikes at each bearing point. The ends of the stringers overlap to provide complete bearing on the pile caps. Spacer blocks are toenailed between stringers with two 60d nails.

DECKING

Standard decking consists of 4- x 8-inch planks, which are spiked to each stringer with two 5/16- x 7-inch spikes, and set with 1/4-inch spacing. Openings greater than 1/4 inch may be used between planks in areas that are subject to heavy rains.

STRINGPIECES

The stringpiece (or curb) is placed on 2- x 10-inch blocking, 24 inches long, spaced on 48-inch centers along the edge of the deck. Stringpiece bolts are countersunk and the hole is seated with bituminous material. (Figure 11-11 shows a wharf-edge cross-section of a timber-pile wharf.)

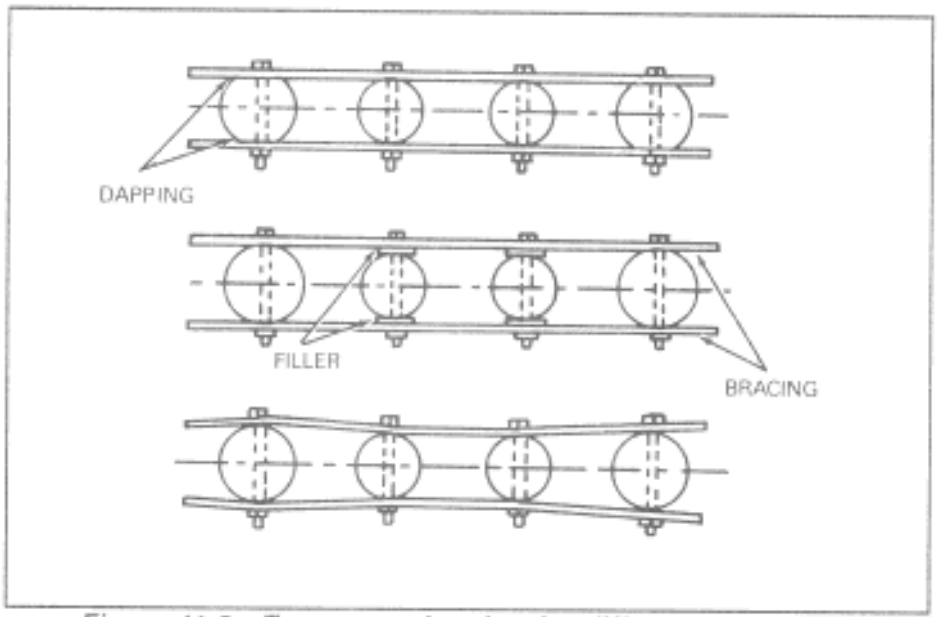

Figure 11-9. Transverse bracing for different size piles

- When the stringpieces are

parallel to the direction of the wharf stringers, the stringpieces are bolted through the blocking, the decking, and the stringer end pieces.

- When the stringpieces are *perpendicular* to the direction of the stringer, they are bolted through the blocking, the decking, alternate stringers, and the pile cap.

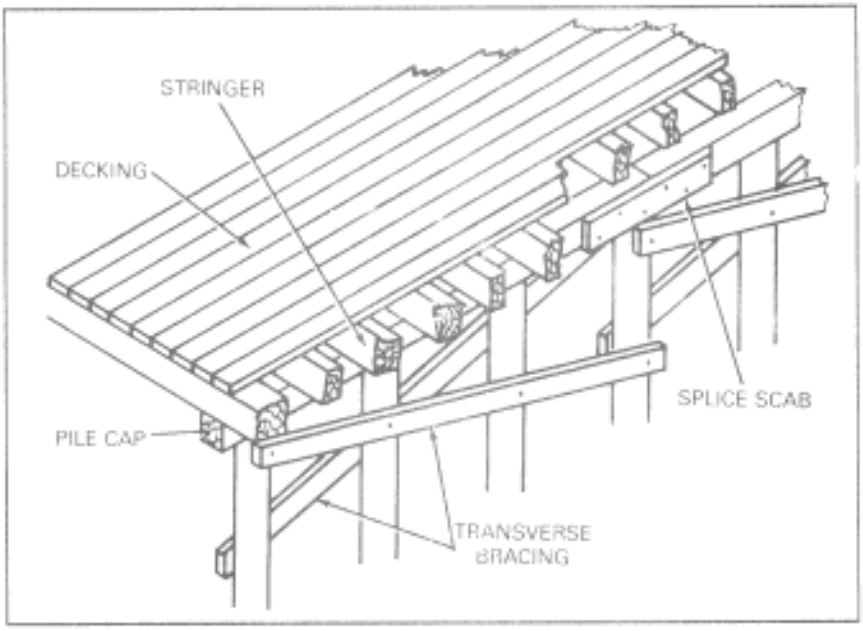

Figure 11-10. Stringers and decking in place

FENDER PILES AND CHOCKS

Timber is the most suitable material for wharf fenders in TO construction. Fender piles serve the following purposes:

- They cushion a wharf from the impact of ships and protect the outer row of bearing piles from damage.
- They protect the hulls of craft from undue abrasion.

The 3- or 4-foot extension of a fender pile above the deck level of a wharf supplements wharf-mooring hardware, but is not used for warping a ship into or out of the berth.

Since fender piles are not part of the structural support of the wharf, they are easier to replace than bearing piles.

Protection of Fender Piles

Protective devices that lengthen the life of fender piles are—

- A heavy timber wearing ribbon, which may easily be replaced. It is sometimes installed along a line of fender piles at the elevation receiving the heaviest abrasion.
- Floating logs or camels (floating fenders).
- Rope wrappings, particularly on corner fenders.

Fender Piles for Quays

Structures that are almost completely rigid, such as solid-fill quays, sometimes have fender piles backed up with heavy springs to give a combination of yield and resistance.

Installation of Fender Piles

Fender piles are driven at a slight batter (angle). Usually 1 to 12 fender piles are used along the outside edge of all rows of bearing piles, except on the extreme inshore wharf sections. Every third

fender pile may extend 3 to 4 feet above the curb. The others are cut off flush with the top of the curb.

Chocks and Wales

Chocks are timber braces placed between fender piles at the level of the stringpiece or pile cap to hold them in position and give them lateral stability. Chock ends should be firmly seated against the piles.

- On *timber-pile* wharves, each chock is fastened with two bolts through the stringer endpiece or pile cap.
- On *steel-pile* wharves, each chock is bolted by 12- x 12-inch blocks driftpinned to the ends of the stringers or bolted to the ends of the wharf pile cap.

Wales (horizontal beams) are used at mean low water elevation when tidal currents are swift or tidal variations are great. Wales add rigidity to fender piles. A 12- x 12-inch continuous longitudinal timber wale is bolted to the back fender of each pile. Timber chocks are placed between fender piles and bolted to the line wales.

PILE CLUSTERS AND CORNER FENDERS

Pile clusters, whether at the faces or corners of wharves or acting as dolphins (isolated pile clusters), must combine beam strength, rigidity, and stability against horizontal stresses. Therefore, the individual piles that make up the cluster must be joined so that the cluster will act as a unit.

Mooring Piles

Clusters of three or more piles are used to supplement or replace wharf-mooring hardware. The top of the cluster is lashed together.

Mooring piles are placed at intervals along the wharf face when bollards and other mooring hardware are not avail able. A maximum of three piles of each cluster extends 3 feet or more above the wharf deck.

Corner Fenders

Piles clustered at exposed corners of the wharf, bolted and lashed together, are provided so that a ship may

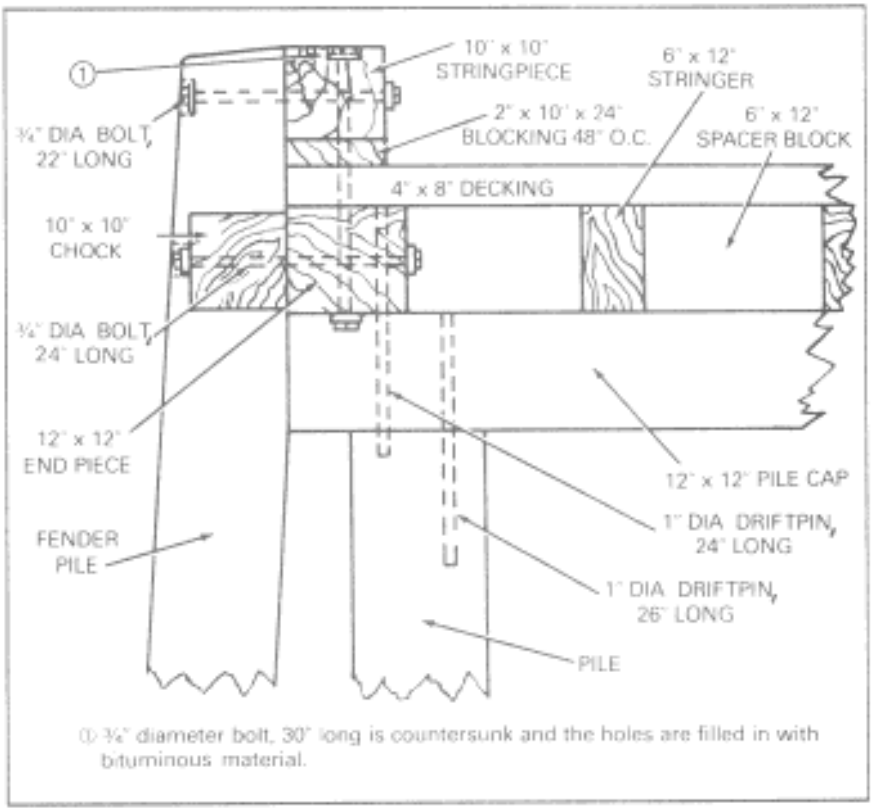

Figure 11-11. Wharf-edge cross-section of a timber-pile wharf

use the corner to pivot when warping in and out of the berth. The wharf is strongly reinforced at the corners with layers of diagonal planking laid one across the other. This reinforcing is backed up with diagonal batter piles.

The standard corner-fender cluster is made up of 10 piles battered for adequate spacing at the points. Timber connectors may be used in conjunction with the bolts to tie the piles more firmly into a single rigid member. To avoid undue abrasion to ship hulls and to outside pile surfaces, heavy rope mats may be lashed to the clusters at the level of contact. To supplement mooring hardware, the corner piles extend 3 to 4 feet above deck level.

Deck Reinforcing on Wood-Pile Wharves. Before stringers are set, wooden piles battered inward are driven to support a cap, set diagonally across each corner, and bolted to the bottom face of the other caps. Another piece of cap timber is set to act as a strut between the fender cluster and the diagonal cap.

The space between the cluster and the diagonal cap is then floored over with two layers of plank each 6 inches thick, laid diagonally (and transversely to each other) to fill the thickness between the cap timbers. To complete the reinforcement, stringers are set close and spiked together over the outer half of each corner panel.

Deck Reinforcing on Steel-Pile Wharves. In steel-pile marginal wharves and piers with corner fenders, the deck in each corner panel is similarly reinforced with timber. Wood piles battered inward carry a diagonal cap timber bolted to the bottom flanges of the steel-pile caps. The diagonal cap is strutted against the fender cluster, the diagonal layers of plank are applied, and the stringers are set close and spiked together, as described above for wood-pile wharves.

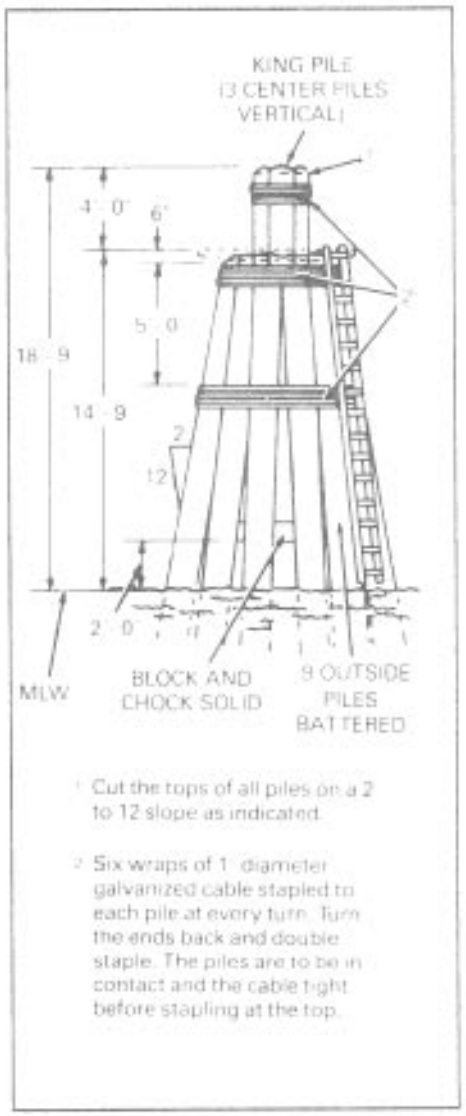

Figure 11-12. Typical pile dolphin

FLOATING LOG FENDERS (CAMELS)

Floating logs are used to absorb part of the impact shock when a ship is berthed. They protect the surface of fender piles while a ship is tied up. The simplest type of fender is a single line of floating logs, each secured by two or more lengths of 1/2-inch galvanized chain fastened to 3/4-inch eyebolts in the fender log and the wharf pile. Some arrangement, such as loose steel collars around the wharf piles, is provided to allow the logs to rise and fall with the tide.

Floating clusters of logs or strongly constructed rafts are called *camels.* In addition to absorbing impact shock and protecting fender piles from the sliding friction of a ship moving in the berth, camels may be required to breast a ship off the face of the wharf into deeper water.

PILE-MOORING DOLPHINS

Dolphins (Figure 11-12 and Figure 11-13, page 11-10) are isolated clusters of piles to which a ship may be moored. The center of the cluster, called a *king pile,* may be a single pile or a cluster driven vertically and wrapped to act as a unit. The other piles are driven in one or more concentric rings around the king pile, each battered towards the center. The king pile is normally left somewhat longer than the others for use as a mooring post.

When composed of a cluster, the king pile is wrapped with at least six turns of 1-inch diameter galvanized wire rope, stapled to each pile at every turn.

Two wrappings of the type described above are used for the pile cluster. One wrapping is located near the top of the cluster and the second about 2/3 the distance above mean low water.

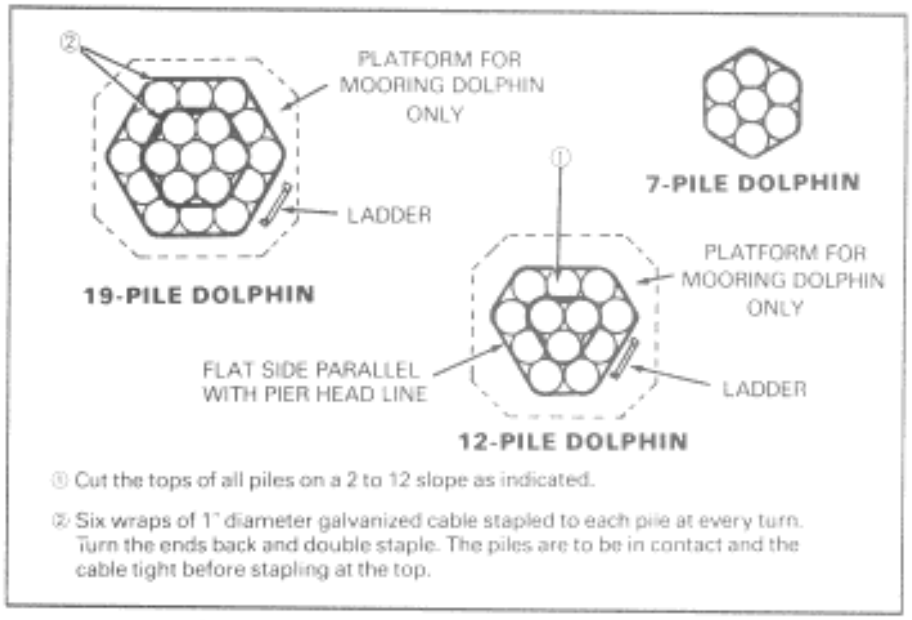

Figure 11-13. Typical dolphin plan views

To further ensure that the cluster will act as a unit, the piles are chocked and bolted together approximately 2 feet above mean low water.

DOCKING HARDWARE

Ships tie up to wharves with lines fastened to mooring fittings such as bollards, corner mooring posts, cleats, chocks, and pad eyes (Figure 11-14).

- *Bollards*, single- or double-bitt, are steel or cast-iron posts to which large ships are tied. They prevent ships' lines from riding up off the post. Bollards may have waist diameters smaller than ton diameters and may have caps, or projecting, rounded horns. Double-bitt bollards are also known as double bitts or double steamship bitts. Bollard bodies may be hollow for filling with concrete after installation They are usually designed to take line pulls of about 35 tons.
- *Corner mooring posts* are usually designed to take pulls of up to 60 tons.
- *Cleats* are generally cast iron, with arms extending horizontally from a relatively low body. The base may be open or closed. Cleats are used for securing smaller ships, tugs, and workboats.
- Open or closed *chocks*, generally made of cast iron, are used for directing and snubbing lines when working a ship into or out of its berth. A closed chock must be used when there is a change in both vertical and horizontal directions of a line.
- *Pad eyes* are metal rings mounted vertically on a plate and intended to receive a ship's line spliced with thimble and shackle. They are used only for securing small craft.

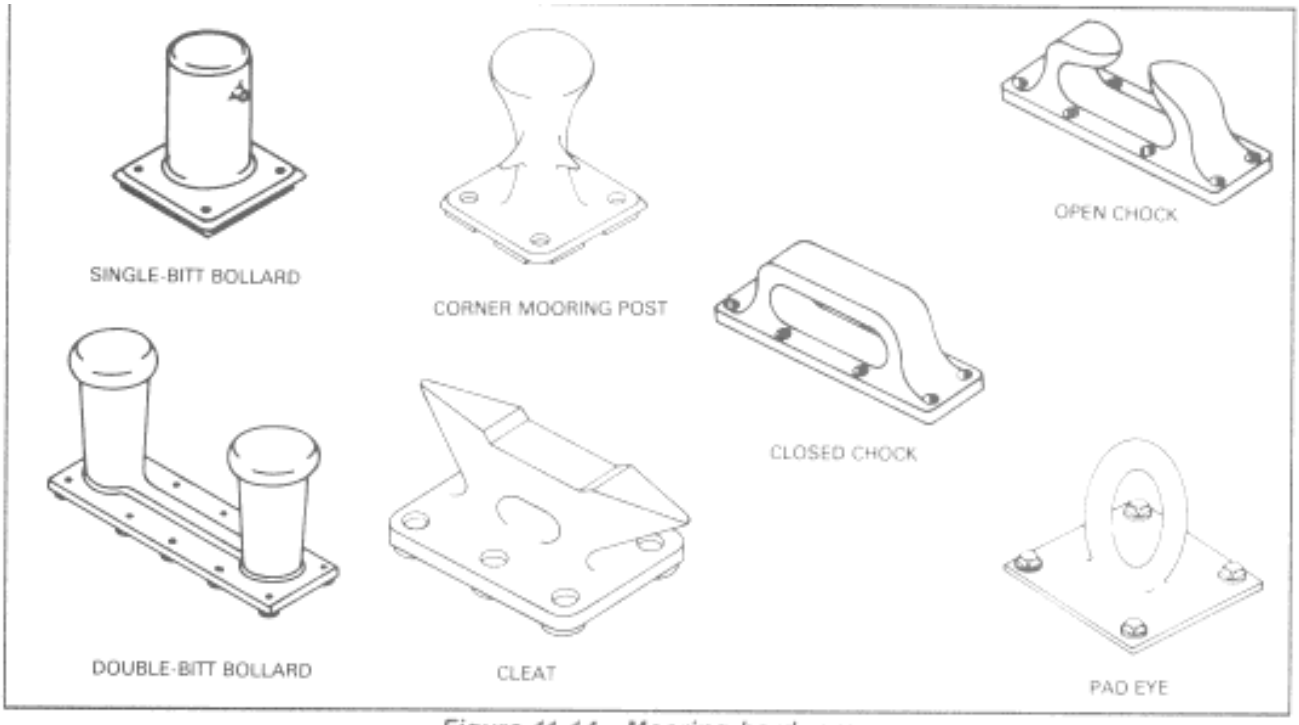

Figure 11-14. Mooring hardware

HARDWARE INSTALLATION

Proper installation requires that the vertical and horizontal stress on any structural unit on which mooring hardware is attached be partially transferred to the wharf structure. This is done by increasing the number and size of stringers under the hardware installation, and by providing anchorage for mooring hardware bolts that will transfer the stress through the pile cap of one or more bents to several piles.

Stringer Reinforcement

The number and size of stringers are increased at the location of major hardware items. When base widths of hardware are greater than 12 inches, but less than 24 inches, at least two 12- x 12-inch stringers are needed. For base widths greater than 24 inches, but less than 36 inches, three 12 x 12-inch stringers are needed; and so forth. Stringers are laid close together and are spiked to each other and at each bearing point. Mooring hardware bolts pass through stringers, filler blocks, and anchorage timbers.

Standard Installation

Standard wharf structures use the following mooring hardware:

- Pier, 90 x 500 feet—six large double-bitt bollards on each side on 100-foot centers and five 42-inch cleats on each side centered between bollards.
- Offshore marginal wharf, 60 x 500 feet— six large double-bitt bollards and five 42-inch cleats spaced as above on the outshore side only.
- Lighterage quay 35 x 500 feet—eleven 42-inch cleats on 50-foot centers.

Nonstandard Installation

For nonstandard wharf structures, mooring hardware should be installed in numbers, types, and spacing approximately that of standard wharves.

When cleats and pad eyes are not available, every third fender pile must be extended 3 to 4 feet above the wharf deck. Fender-pile extensions may be used to steady a ship in the berth, but not to winch a ship into position.

On berths located near enough to the shore, bollards or mooring posts may be located onshore.

Location

Bollards and other mooring hardware are placed clear of cranes and traffic and as close to the curb as possible. Onshore mooring anchors should be located so that the lines will not have to be moved for traffic.

ANCHORAGES FOR HARDWARE

The following paragraphs explain the different types of hardware and their uses:

Location Between Pile Bents

To provide anchorage for heavy items of mooring hardware located between pile bents, a grillwork of 12 x 12 timbers is bolted underneath the pile cap (Figure 11-15). Each of the four piles directly affected by the upward pull on the grillwork is strapped to the pile cap with 3- x 3/8-inch steel strapping. The straps are spiked to piles and pile caps. Filler blocks of 12 x 12 timbers are centered to receive the mooring hardware bolts.

Location on Pile Bents

Mooring hardware is also located directly over the outside bearing pile of a bent as shown in Figure 11-16. Mooring hardware with 22- to 26-inch bolt centers is anchored as follows:

- Two 12 x 12 by approximately 20-foot-long timbers are bolted under the pile cap over which the hardware is located and to both sides of three piles of the bent.
- 12 x 12-inch filler timbers approximately 4 feet long are bolted to the wharf pile cap under the hardware bolt location.
- Each of the three piles directly affected by the upward pull on the

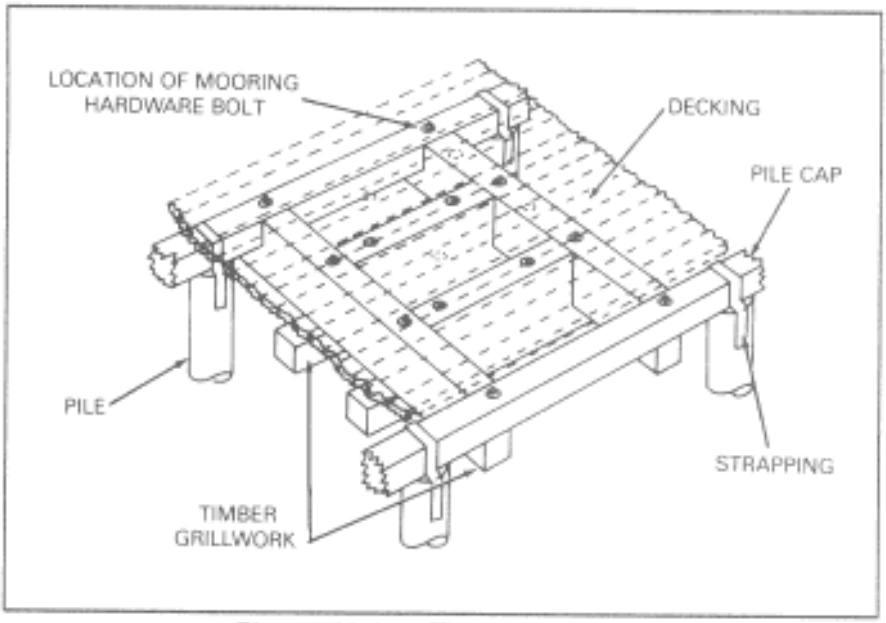

Figure 11-15. Timber grillwork

grillwork is strapped to the pile cap with steel strappings as described above (see Figure 11-15).

Items of mooring hardware with bolt centers greater than 26 inches require using timber wider than 12 inches or doubling the number of timbers, or locating the hardware between bents using the timber grillwork anchorage described previously.

Bracing

The wharf structure is longitudinally braced at the location of bollard installations. Diagonal bracing is done from just below the pile caps to about low-water level at the location of each bollard. The cross bracing is bolted to each pile.

Installation of Light Items

Light items of mooring hardware with bolt centers less than 8 inches, such as cleats, chocks, and pad eyes, are bolted through the stringpiece, blocking, decking, and stringer end piece.

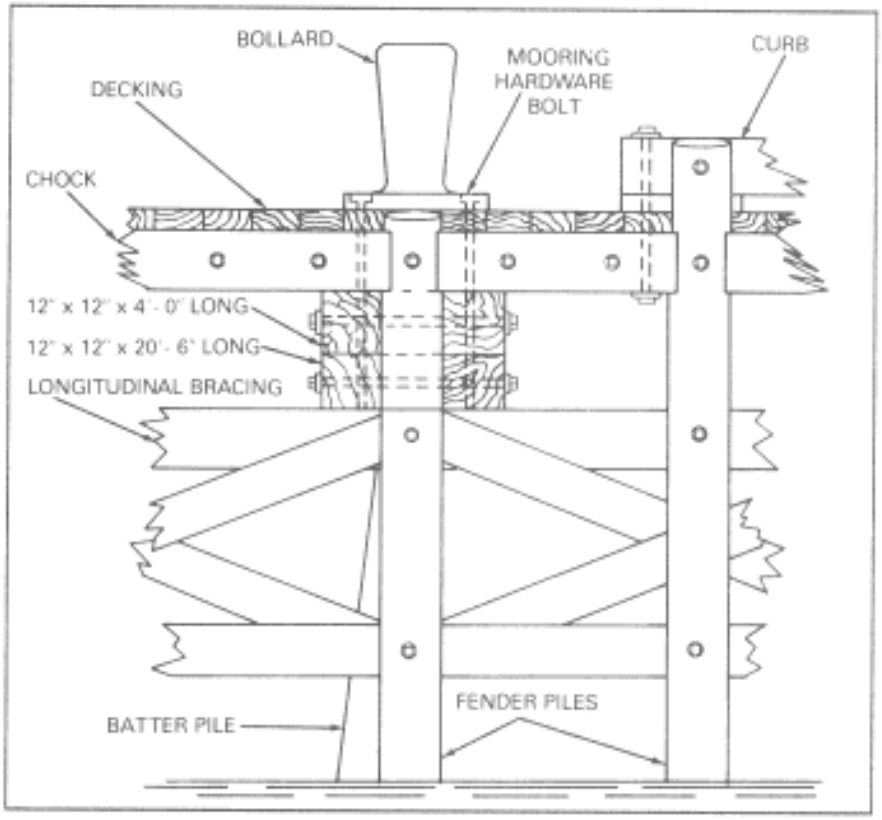

Figure 11-16. Mooring hardware over bearing pile